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The PT-30/35-8.8/1.0-5M and PT-40/50-8.8/1.0 Steam Turbines for Replacing Turbines of the VPT-25 Family

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Abstract—The basic design features and technical characteristics of the turbines installed on the foundation of turbines of the VPT-25 family are presented.

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At present, almost all of the main steam-turbine equipment operating at power stations of Russia, former Soviet republics, and foreign countries that was installed in the period from the 1950s to 1979s have worked out their fleet life and even far beyond it, having been in operation by 2010 for as much as 380–410 thousand h. Power units equipped with turbines of the VPT-25-90-3(4) family account for the largest fraction of the equipment installed at that time. It should be noted that the OAO Turbine Engine Works, presently the ZAO Ural Turbine Works (UTZ), alone has manufactured 187 such turbines. The geography of places to which turbines of this type were supplied is very broad: they are installed in Russia, Belarus, Kazakhstan, Ukraine, Kirgizia, Turkmenistan, Tajikistan, Azerbaijan, Uzbekistan, Moldova, Georgia, Bulgaria, Romania, Poland, and Egypt. Thirty-seven turbines of this type were also produced for China. Although the majority of these turbines still remain in operation, but undoubtedly, they need full replacement.

UTZ specialists have designed the PT-30/35-8.8/1.0-5 turbine that has better economic indicators (Fig. 1). The pilot model was installed in 2005 at the cogeneration station of the Ural Railway Car Works, and the second similar turbine (PT-30/35/8.8/1.0-5M) referred to henceforth as a PT-30 turbine equipped with an electrohydraulic control and protection system was commissioned in 2009 at the Nevinnomyssk district power station.

The foundation frames on which the PT-30 turbine is installed are by 329 mm shorter than those for the VPT-25-4 turbine; therefore, the new turbine is installed on the pedestal of the dismantled turbine without making many changes to it.

The turbine has a welded-and-cast cylinder. Steam driving the turbine is admitted to it from a standalone stop valve through four control valves installed on the turbine shell. The turbine flow path consists of 18 stages, the first of which is the control stage. The disks of stages 1–10 are forged together with the shaft. The control stage consists of two buckets with a mean diameter equal to 925 mm. The rotor blades of stages 2–10 have a root diameter of 905 mm. Steam for process purposes is extracted after the 10th stage; the steam pressure is maintained in the majority of operating modes by means of the control diaphragm of stage 11. Steam for heating purposes is extracted from the chamber installed after stage 15. Steam pressure is controlled by means of a tight control diaphragm of stage 16. Since the last-stage blade is only 432-mm long and can operate at low flowrates, the minimal flowrate of steam to the condenser during operation of the turbine in accordance with a heat load schedule is equal to 4 t/h.

The turbine regeneration system (Fig. 2) includes three low-pressure heaters, a deaerator, and two high-pressure heaters. Spent steam is removed into a K-1700 condenser (the cooling water flowrate is up to 5000 m^3/h) made without a built-in bundle.

The retrofitting of a power station often includes, apart from replacement of the turbine, replacement of its boiler equipment, during which new modernized boilers with an increased steam output are installed on the same foundation. In addition, at cogeneration stations with transverse links it becomes possible to increase the flowrate of live steam to the retrofitted turbine by redistributing the flowrate of steam that was supplied to decommissioned turbines. For such cogeneration stations, the PT-40/50-8.8/1.0 turbine having the maximal steam flowrate increased to 265 t/h can be proposed. This turbine has been designed on the basis of the PT-30 turbine and can also be installed on the foundation of the VPT-25 turbine. Such turbines are supposed to be installed at the Novokuibyshev, Sogrinsk (Kazakhstan), and Vitebsk (Belarus) cogeneration stations.

To achieve higher throughput capacity of the stage that controls the process steam extraction in the PT-30 turbine, the pressure stage located directly after the control stage has been removed in this turbine. However, this measure does not make it possible to maintain steam pressure equal to 0.98 MPa in modes with

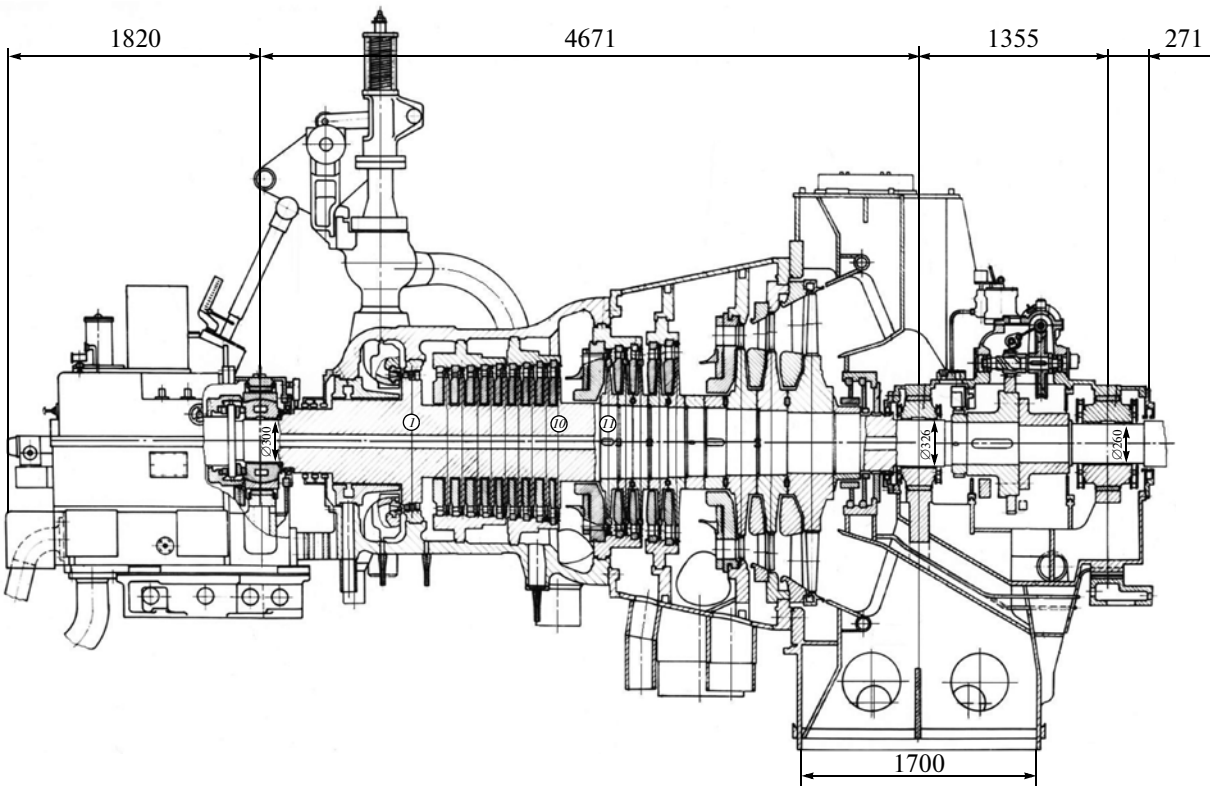

Fig. 1. The PT-30/35-8.8/1.0 steam turbine.

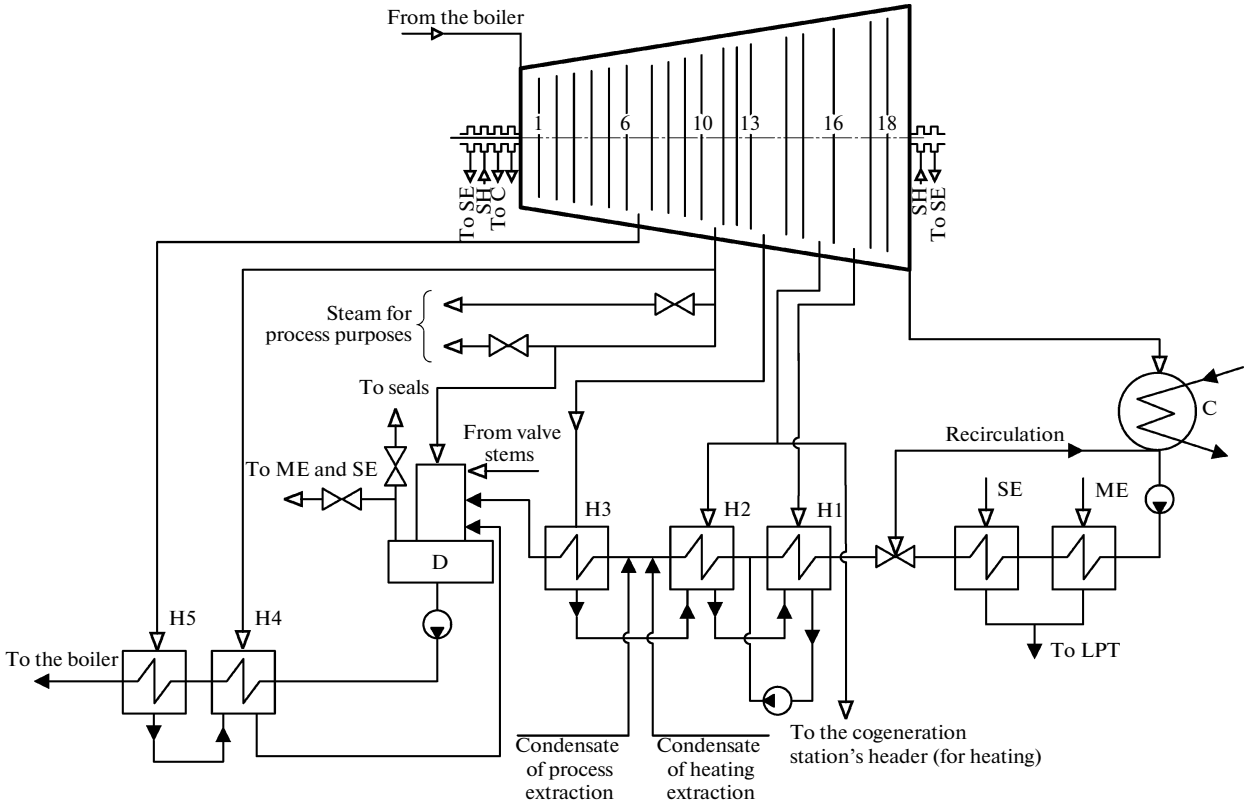

Fig. 2. Basic thermal circuit of the PT-30/35-8.8/1.0 turbine unit. H1–H5 are regenerative heaters, D is the deaerator, C is the condenser, SE is the seal ejector, ME is the main ejector, SH is the seal header, and LPT is the low-point tank.

Main indicators of PT-30 and PT-40 turbines

Indicator	PT-30/35-8.8-1.0-5M		PT-40/50-8.8/1.0	
	Operating mode			
	rated cogeneration	condensing	rated cogeneration	condensing
Live steam parameters				
pressure, MPa	8.8	8.8	8.8	8.8
temperature, °C	535	535	535	535
rated (maximal) flowrate, t/h	190 (240)	116	240	202
Process steam extraction				
pressure, MPa	0.98	–	0.98	–
rated (maximal) flowrate, t/h	83 (160)	–	100	–
District heating steam extraction				
pressure, MPa	0.12	–	0.098	–
rated (maximal) flowrate, t/h	63 (93)	–	80	–
Condenser				
water temperature, °C	20	20	20	20
steam flowrate, t/h	10	88.3	13	147.8
steam pressure, kPa	3.5	5.1	3.5	9.0
Electrical capacity, MW	30	30	40	50
Heat rate, kJ/(kW h)	–	10249	–	10241
Steam rate, kg/(kW h)	6.33	3.87	6.0	4.04

limited extractions of process steam. The required pressure of steam is maintained by a control valve installed in one of the pipelines. The removal of steam through the second pipeline is prevented by closing a gate valve. The indicators characterizing the performance of the turbines during their operation in the main modes are summarized in the table.

The regeneration system of the PT-40 turbines remains the same as earlier. The turbine unit also includes a K-1700 condenser.

The VPT-25-4 turbines were supplied together with TVS-30 and TVS-32 generators. For the generator pedestal to be used, it is advisable that the PT-40/50-90/20 be supplied together with a T3V-63-2 generator with full water cooling produced by OAO Silovye Mashiny (Power Machinery) or with a new specially developed TF-50 generator with air cooling produced by NPO ELSIB, which are installed on the pedestal of the old generator without making essential changes to it.